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Land of Hardwoods

1963 Annual Report

Central States Forest Experiment Station

U.S. Dept. Agriculture • Forest Service

Columbus, Ohio • R. D. Lane, Director

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EXPERIMENT STATION

How many of the fine central hardwoods shown on our cover can you identify? If you get stuck, here are the eight species listed in order from left to right, beginning on back cover: red oak, white ash, butternut, sycamore, hickory, yellow-poplar, walnut, white oak.

Foreword

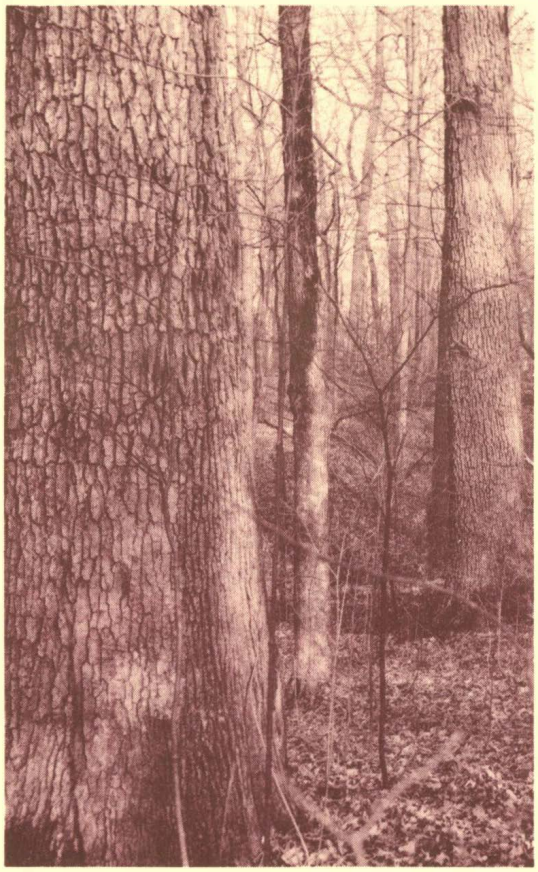
Periodically, we at the Central States Forest Experiment Station stand back and take a broad look at the region's forest resources and forest research needs. We look at our programs, at progress we and others are making in solving critical forestry problems in the region, and at new research needs in light of changing conditions. Such an appraisal has been in progress for the past few months.

Because we want to share some of our reflections with you, this year our Annual Report diverges somewhat from the common practice of summarizing current research progress. However, we've still included research results along with discussions of resources and problems. In keeping with custom, our current publications are listed. Most of them are available if you do not already have copies.

One point is self-evident — the Central States region is hardwood country. There are some natural stands of softwoods, for example shortleaf pine in Kentucky and Missouri, and some softwoods intermixed with hardwoods. And there are many coniferous plantations throughout the area. But the total coverage is small; hardwoods occupy most of the forest land.

So, our research program is now being oriented heavily, although not exclusively, to the problems of protecting, managing, and utilizing hardwood forests.

R. D. Lane
Director



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Land of Hardwoods

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The Central States region is hardwood country. In no other major region of the Nation do broad-leaved species so dominate the forest scene as they do in the six central states, where they occupy 98 percent of the forest land. Truly then, this is the "Land of Hardwoods."

The original hardwood forest in the Ohio Valley must have been something to behold! In 1817, for example, white oaks 6 feet through and 80 feet to the first limb were reported to be plentiful in Ohio. With 95 percent of the State forested, conservative estimates set the average timber volume per acre at 12,000 board feet.

But these great forests lay right in the path of history. When the surge toward the West began 150 years ago the forest was both a boon and a bane to progress. The trees stood over land that was needed for homesites, farms, roads, and towns. So down they came. And yet these same trees provided the early settlers with many of the necessities of life: food, shelter, heat. In fact, it could be said that without the products of the midwestern forests, the West might not have been "won."

Despite the early ravages, the forest was not completely destroyed. One acre out of every five in the Central States is still forested. This remnant — 42 million acres of it — represents an important resource, even (or perhaps we should say, *especially*) to a region whose economy is primarily agricultural and industrial.

Let's take a closer look and see just where this resource is, what it is, and what is happening to it. A recent up-dating of forest resource information makes it possible for us to get a current picture of the present forest situation as well as note any trends that have shown up during the past decade.

The bulk of the forest land in the Central States is in the southern part of the region: in Kentucky and Missouri which contain more than 60 percent of the forest, and in the hilly southern parts of the northern tier of states. Most of this forest land is unsuited to farming and so probably will remain wooded. The rest of the forest is scattered in small, privately owned woodlands with a few larger pockets in localized areas such as northwestern Illinois and northeastern Iowa.

Ninety-two percent of the forest land in the Central States is privately owned, sixty percent of it by farmers.

About two-thirds of the forest is in the upland, oak-hickory type. The moist-site, elm-ash-cottonwood type accounts for another fifth of the forest area. Most of the remainder is in other hardwoods; softwoods make up only about 2 percent.

So much for the forest land itself. Now what about the timber that is growing on it? Total sawtimber volume is 86 billion board feet. This sounds like a lot of lumber. But spread out over the region's forest land it amounts to about 2,100 board feet per acre — sparse stocking for growing high-quality hardwoods. From the viewpoint of bulk volume, however, the situation is better than it was 10 years ago. Total cubic-foot volume has increased about 15 percent, to a total of nearly 26 billion cubic feet. This is encouraging of course, but somewhat deceptive. Taking a closer look we find that sawtimber volume has increased by 8 percent, only half as fast as total cubic-foot volume. This means that most of the "growth" is not really big trees growing bigger but small trees "coming of age," i.e. growing large enough to be counted and measured. Not much consolation here for the sawmiller or veneer manufacturer who needs logs now, but opportunities for the future are excellent because we have a young forest that still can be molded to our needs.

The fact that total timber volume is increasing suggests that timber is growing faster than it is being cut. Rate of growth, in fact, is more than double rate of cut despite the fact that hardwood pulpwood consumption in the region more than doubled from 1957 to 1962 and is now well over half a million cords. Does this mean that demand for quality hardwoods is diminishing? Hardly — especially when you consider that the Nation imports nearly half the wood used for hardwood plywood and veneer. So, we're growing quantity, but we're not growing quality. And quality is what the major hardwood markets demand.

In spite of the fact that the Central States contain only 12 percent of the Nation's forest land, two of these states, Illinois and Ohio, ranked fourth and fifth in the country in 1958 in value of goods and services attributed to wood-using activities. In the same year the value of rough timber products harvested from these six states and delivered to the point of use was set at $100 million. Value added annually by manufacture in all timber-based economic activities amounted to $4 billion. And these industries employed more than half a million full-time workers.

Impressive figures? Yes indeed! But their real significance lies in the potential they reveal. We know that the Central States region is fully capable of producing fine hardwoods. We know that the region's economy is geared to utilizing hardwoods and that the under-used labor force in areas where our forests are concentrated would benefit greatly by any increased economic activity.

The forests of our region, we also know, protect vital watersheds, provide a variety of recreational opportunities and support large numbers of game animals and birds that are heavily hunted. Moreover, in some areas, associated ranges make significant contributions to the local economy. We know less about these resources than we do about timber but are coming to believe that, in some situations, they may become the dominant uses of our hardwood forests. In still other situations, harmonious adjustments of resource uses may yield the optimum benefits to forest owners and to the public.

Clearly then, there are many opportunities for hardwood forestry to play a larger role in the economy of the Central States region. But hand in hand with opportunity go challenges. To help meet these challenges, the Central States Station research program is being oriented heavily, but not exclusively, to hardwood forestry. Some of the challenges and some of the ways our work is now contributing to the protection, management, and use of the region's hardwood forest resources are described in this report.

Protecting Hardwood Forests

Regrettably, trees have enemies — even hardwood trees. While the forester is growing trees with one hand he must fight off insects, disease, and fire with the other. So far in the central hardwood region the battle against pests (to say nothing of fire) is a draw: insects and diseases get half of each year's timber harvest; man gets the other half. It is part of our research job to find ways to tip this balance more in man's favor.

INSECTS

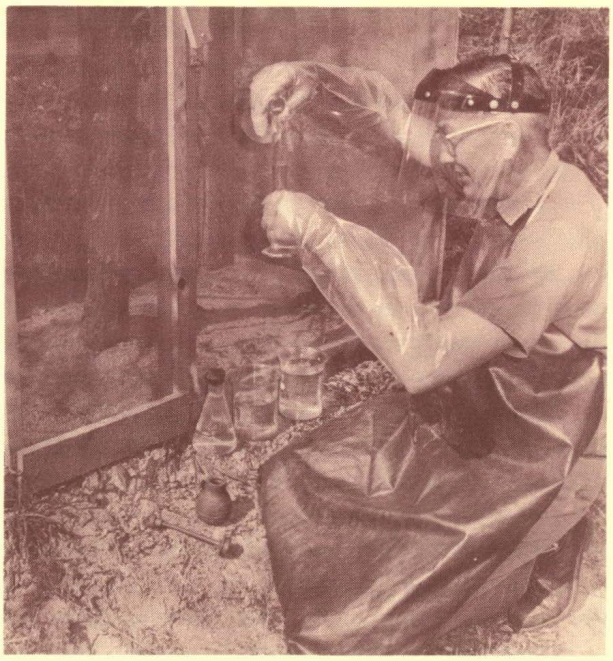
Insects attack and destroy timber in three direct ways. Most obvious of course is the direct attack where the bugs themselves inflict the casualties. Some insects kill or retard the growth of trees by eating the foliage. Others weaken a tree by sucking vital nutrients from various parts of it. Still others bore into and through the wood itself thus destroying its value as potential high-quality lumber.

In addition, insects carry disease organisms, airlifting them from diseased trees to healthy ones. The smaller European bark beetle, carrier of the Dutch elm disease, is the most familiar example of this. And by their direct attacks (mentioned above) some bugs so damage and weaken a tree that it becomes readily susceptible to infestation by disease organisms.

Our scientists in the field of biological control are planning counterattacks on major insect enemies of central hardwood trees. Long before the current furor over the use and misuse of insecticides, our research entomologists anticipated the problem and began taking steps to alleviate it. We are still working with insecticides to be sure, but we are seeking new, safer, and more effective ways to apply them. And more importantly, we are putting more and more emphasis on biological control, less and less on chemical. In effect, we are calling in new troops as well as developing new weapons. Let's consider some examples.

One of the strongest objections to the use of insecticides is the danger that they will kill or harm other forms of life — beneficial insects, birds, wildlife, pets, farm animals, and so on — as well as the intended victims. So we are trying to find practical ways to apply systemic insecticides to trees, i.e. getting the chemical *into* the tree instead of *onto* it. In one of our studies we have been using the thornless honeylocust tree as a guinea pig. This tree's usefulness and beauty as an ornamental are often impaired by the activities of the mimosa webworm. We have developed a safe and economical technique for treating individual trees with a systemic insecticide. It goes

Chemosterilants are carefully measured and handled so that their effects on the reproductivity of locust borers can be precisely evaluated.



like this: remove the soil from over several buttress roots of the tree to be treated, about a foot out from the trunk. Then drill ¼-inch-diameter holes into the roots and place a small amount of the systemic insecticide in each hole. Replace the soil and the job is done. The chemical will be translocated to the foliage where it will kill feeding insects but will leave no surface residue harmful to man, birds, or animals. A tablespoonful of the proper chemical applied in this way will protect a 10-inch-diameter honeylocust from mimosa webworm attack for at least a year. Although chemical insecticides are involved in this method of control, it is still properly called "biological" control because in effect the tree is rendered immune to attack by internal treatment.

Another method of biological control that involves chemicals but uses them in an entirely different way is being studied. In this work the locust borer is the guinea pig. This pest riddles the stems of black locust trees with tunnels, destroying the wood. It is especially serious in pure, young plantations of black locust, such as are planted on strip-mined land in the Central States. The strategy here is to feed adult male insects a "chemosterilant," i.e. a substance that will sterilize them. Every male that can be induced to sterilize himself in this way will in turn prevent about 10 females from producing young, thus greatly reducing the population potential of the next generation.

Still another biological approach to insect control is exemplified by the technique our entomologists developed for controlling the red oak borer. The larva of this insect is to red oak trees what the locust borer is to black locust; it can completely destroy the potential lumber in an otherwise prime tree. A detailed study of this insect in Kentucky revealed that it has a synchronized, 2-year life cycle, i.e. eggs are laid only in odd-numbered years. Furthermore, a vulnerable spot was found in the life cycle: during the first year larvae work in the inner bark phloem, the living part of the stem, and so die if the tree dies. The control method recommended then is to do logging and stand improvement work between July of the odd-numbered years and May of the even-numbered years. Simple, but it works! Evidence is building up that the red oak borer is the precursor of the wood-destroying carpenterworm. If this be the case, we may be able to control two hardwood insects with one treatment!

These are examples of biological controls for insect pests we are working out for the central hardwood forests — controls that already have proved successful or that show promise for early success. But what about the future? Are new avenues of approach being considered and explored? Yes, indeed. Just for example: our entomologists asked themselves, "Why does an insect attack a tree anyway? And why are most insects so selective, attacking only certain species?" There must be something about the American elm, for instance, that attracts the smaller European bark beetle. What *is* it? To find out, we are attempting to extract various chemical compounds from elm bark so that we can incorporate them into artificial media and evaluate the feeding response of the beetle to them. Success in this effort could lead to an entirely new kind of campaign in our war against the insect enemies of central hardwoods.

DISEASES

Disease is the worst single enemy of central hardwood forests. In its various forms, it causes 45 percent of the sawtimber volume and growth loss in the region. Our forest pathologists have marshalled their forces against the major hardwood disease problems including vascular and virus diseases, hardwood cankers, heartrots, and physiogenic disorders.

During the past 10 years we have paid special attention to oak wilt, a lethal vascular disease, which is potentially the most serious threat to oak sawtimber production in the United States. The key to the oak wilt problem lies in finding out how the disease spreads. We know that it can spread from tree to adjacent tree by means of root grafts but the amount of spreading that occurs in this way appears to be negligible. Most investigators now agree that oak wilt is probably spread by insects. Prime suspect so far, in Missouri at least, is the small oak bark beetle. Our evidence to date, however, is circumstantial: the beetle breeds in infested trees; as many as one-third of the beetles

Sample cores removed from oak logs fumigated with methyl bromide will be cultured in the laboratory to find out whether the treatment has successfully killed the oak wilt fungus.

in a brood emerging from diseased trees carry the fungus in viable condition in as well as on their bodies; and the beetles feed on healthy oaks in such a way that, if contaminated, they could introduce the fungus into these trees. Still, we have not yet caught the rascal redhanded! So the search goes on.

Success appears nearer, however, on another phase of the oak wilt problem. Several countries have placed embargoes on imports of oak timber from the United States unless such timber can be certified free of oak wilt fungus. Research at the Station has developed a promising method of fumigating oak logs, thus killing the fungus. In the laboratory, several fumigants killed the fungus in small bolts of diseased wood. The most promising of these, methyl bromide, is now being evaluated with saw logs under field condition.

Another part of our research effort is directed toward the hardwood cankers, particularly a new bark canker disease of yellow-poplar which we described in 1962. At first this disease seemed to be localized in Ohio but it has since been found in Indiana and Virginia. The cause has been determined to be the fungus *Fusarium solani* ([Martius] Appel and Wollenweber). Further study has shown the disease to be a virulent pathogen only when the host is weakened by unfavorable environmental conditions and wounded so as to provide an entrance court. Sound, healthy trees do not seem to be susceptible.

FIRE

Protection from wildfire is essential in the management of hardwood forests of the Central States. Young trees are easily injured and may be top-killed by fires. Injuries may lead to disease and insect attacks that cause degrade in logs, cull, or even eventual death.

Forest management and protection, employed to develop good growing stock from the decadent, much-burned woods of 30 years ago, have caused many changes in amount, kind, and character of fuels. This in turn requires changes in fire protection plans, and firefighting equipment and methods.

Protection from fire alone has permitted development of humus, compacted organic materials, and loose litter. Such accumulations form a desirable biological complex. But they also provide 7 to 9 tons per acre of fast-drying, combustible fuel in which wildfires start easily and spread rapidly. A major part of our fire research program is devoted to evaluating the fuels and changes in fuels in Central States hardwood stands, and currently to adapting the new National Fire Danger Rating System for use as an effective fire-control-planning tool. We are measuring and evaluating the fuel on the ground, in standing trees, and in dead stems resulting from timber stand improvement and harvest cuttings. Few if any trees can survive the intense fires possible in the accumulation of logging slash or heavy fuels that results from clear cutting. We are working toward better means of fire-danger estimation to provide warning of dangerous situations so that firefighters can be better prepared for a misplaced match.

Hardwood Resource Management

Hardwood forests have many uses: they grow timber and timber-related crops, protect watersheds, produce forage on associated ranges, provide recreation sites, and harbour and sustain wildlife. A part of the progress we are making and some of the unsolved research problems that lie ahead in timber, water, recreation, and range resource management are discussed here.

TIMBER PRODUCTION

In managing a hardwood forest for timber production, the forester needs a wealth of knowledge. He needs to know, among other things, site and species relations, how dense to grow his stands, and how to regenerate his forest. Then he needs to pull this knowledge together and develop a management system. Our research has now progressed far enough in these areas to give the hardwood forester some of the significant ingredients for his management system.

Site and Species

One of our principal research objectives is to find ways to classify upland sites according to their capacity to grow various tree species. Past forest treatments have obliterated indicators frequently used to evaluate site. So, we turned to the soil itself and to topography and are studying their effects upon the growth rate of various key species. This research is far from complete but here is what we have found so far:

- Good sites occur on lower slopes and in coves and on many north and east middle slopes. Surface soil is deep, friable, and well drained. Organic matter is abundant. Best trees to grow on these good sites include such high-valued species as black walnut, black cherry, white ash, and sweetgum, as well as yellow-poplar, northern red oak, and white oak.

- Most of the upland hardwood area in the region is medium site. This includes most midslopes and upper north slopes and many of the lower south slopes and broad flat ridges. Surface soil is fairly deep. Preferred species are again yellow-poplar and northern red, white, and black oak.

- Poor sites are the upper south slopes and high, dry ridges with shallow rocky soil. Species that do best here are some of the red oaks.

Stand Density

Once the question of site and species has been settled, the next thing the forest manager has to worry about is density. Upland central hardwoods can fully utilize a site throughout a wide range of stand densities. Growth rate per acre will be about the same for all stands that range from 60 to 100 percent stocking. Growth of individual trees will differ greatly within this stocking range of course: trees in stands at the lower end of the range will grow faster but there will be fewer of them; trees in stands that are more fully stocked will grow slower but growth will be spread among a greater number of trees. In general, if a stand is less than 60 percent stocked, space is being wasted; if a stand is more than 100 percent stocked, growth is being sacrificed and mortality increases.

Here again we still have much to learn — for example, what are the effects of stocking upon tree quality and what is the optimum stocking for growing specific products? Comprehensive studies are underway now to answer these and similar questions.

Regeneration

From research, observation, and experience we've concluded that the best way to regenerate the most desirable species in our hardwood for-

Clear-cut opening after 5 years.

ests is by clear cutting. This conclusion has raised a few eyebrows — even our own.

We've discovered that openings in our forest stands give us the kinds of natural regeneration we want. The reason for this is basic: the species we want most are intolerant and will not reproduce well in the shade. We've also discovered that there doesn't seem to be an opening that is too large. Even clear-cut areas as large as 25 acres have yielded thick stands of yellow-poplar and oak.

These findings led to a search for seed sources that gave us this abundant reproduction. Our studies show that it is the usual thing in oak stands for acorns to germinate, die back to the ground, then resprout and die back year after year until they are finally released. Then they survive and grow. So the stand of oak reproduction that finally emerges when the overstory is removed consists of stems the same age but roots of various ages. And the fact that most of the roots are several years older than the stems gives unusual impetus to the stems, making them grow faster and compete more favorably with the inevitable weed species.

A parallel situation prevails in the case of yellow-poplar. We have found that seed of this species may lie dormant in the litter for several years (at least four) without losing viability. Again, when the overstory is removed, these seeds germinate all at once forming a thick, even-aged stand of reproduction. This is a fast-growing species naturally and will usually dominate the competing brush in a short time.

Management System

As the above and other evidence from our research throughout the central hardwood region accumulated, a general system for upland hardwood management began to emerge. This is the way it works:

First, divide your forest into small management units, each unit being as homogeneous as possible in terms of site and stand condition. A unit should be large enough to give you elbow room in manipulating the stand but small enough so that all of it can be seen from one point. Somewhere between ½ acre and 5 acres.

Next, consider each unit separately and decide what is the "main" stand — the one you are going to manage. This main stand may range anywhere from waist-high reproduction to mature sawtimber, the only criteria being that the trees all be of approximately the same size and that they cover at least 60 percent of the growing area. Now, looking at these trees and ignoring whatever others may be on the area for the moment, you are faced with the question: What needs to be done to favor this stand? You have three choices of course: make a harvest or regeneration cut, make an intermediate cut, or do nothing.

If your main stand is mature merchantable sawtimber that is at or near 100 percent stocking, you are ready to harvest the stand and begin all over again. The key to making this harvest and regeneration cut is to cut or kill *everything larger than 2 inches in diameter.*

If, at the other extreme, your main stand is a new one, seedlings or small saplings, your chief immediate concerns are species composition and distribution. Select crop trees spaced about 20 feet apart from among the dominants and co-dominants of the desirable species. These 200 or so trees per acre are the ones you will favor in all subsequent cultural operations. If many of these trees are crowded or in danger of being over-topped, a thinning or improvement cut may be necessary. The secret in making such intermediate cuts is to *remove only those trees that are interfering with the growth of your selected crop trees.* Every stroke of the ax or swipe of the saw costs money so you don't want to waste any of it just to make the stand look pretty.

Thinning should be repeated whenever necessary, i.e. when the stand approaches 100 percent stocking, so as to maintain rapid growth. But beware of thinning too heavily (below about 60 percent stocking) because this wastes growing space and encourages epicormic branching. Stop thinning when the stand approaches maturity — 60 to 70 years for oaks on medium sites — because removing the periodic growth at this stage will not do enough good to enough trees to make it pay.

Should, by chance, the dominant and co-dominant trees in the stand you have chosen to manage all be of desirable species, well spaced, and free to grow, there is no immediate need to do anything.

We feel that we are making progress in central hardwood timber management research. But we readily acknowledge that we still have a long way to go. We are constantly beset by questions yet unanswered: Will the management system being developed for upland hardwoods apply to bottomland hardwoods? Is it practical to supplement natural regeneration by planting hardwoods? Can planting help us replenish our diminishing supply of "precious" hardwoods such as black walnut? Can agricultural practices be adapted to planting and growing high-valued hardwoods? How can we grow high-quality timber in the shortest possible time? Does pruning have a place in hardwood timber management? How can growth rate and quality be improved through genetics? And how can we make our systems of hardwood timber measurements more precise?

All of these questions and more are receiving our attention right now.

WATER

Another important hardwood forest resource is water. Vegetation, especially forest vegetation, has long been recognized as a protector of watersheds and a regulator of water. As water demands become greater our need for knowledge about physical laws governing water movement on forested watersheds will become greater too. We need to know now about how these watersheds function, how to manipulate forest cover to our advantage, how to protect and restore them, and how to predict water runoff from them. Much of our water research is directed towards these objectives.

A big gap in our knowledge is in the realm of underground water behavior. For example, how deep is water absorbed into the soil before it begins to flow horizontally? How fast is this horizontal flow? What soil factors influence it? To answer these and similar questions we have research underway in Ohio. Early results of this work indicate that horizontal seepage beneath the surface is remarkably fast (about a foot per hour), especially when there is a layer of dense soil (clay) or rock near the surface that impedes the downward flow. These studies have also verified the little-known fact that water in a typically layered forest soil may not always run downhill. Thus, because of the physics involved, water in a seemingly dry layer of sand may be drawn *upward* into a seemingly moist layer of clay above it.

We have been conducting research in forestation of surface-mined land for many years and dependable tree-planting guides have been prepared. However, surface mining of minerals in the rough hardwood forest watersheds of the Appalachians creates many new and tricky problems in protecting all forest resources during mining and

The capacity of the soil on these wooded hills to absorb and transmit water from rainstorms directly affects the amount of water that flows in this stream.

restoring them after the operation is finished. The principal problems we have selected for our strip-mine research project at Berea, Kentucky, are: (1) location and protection of haul roads; (2) earth movement and placement; (3) chemistry of the overburden and spoil banks; (4) hydrology; and (5) restoration of forest resources. From this research we will develop alternative forest uses for mined areas that can be selected in advance and provided for in the mining operation. At the same time we will develop guides for protecting and restoring forest resources during and after mining.

Even though our research in protecting and restoring water and other forest resources on these banks in the Appalachians is relatively new, some results are already available. For example, accurate predictions of the area below a proposed mine that would be covered by spoil would facilitate planning to protect roads, streams, timber stands, and similar values. To meet this need, we have developed a formula and charts that make it possible to predict this coverage before mining begins.

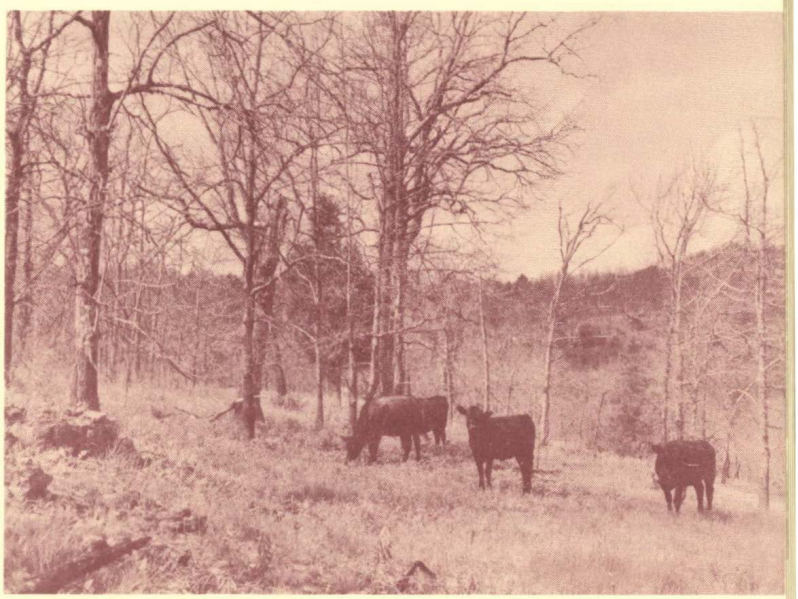
RANGE

In the Ozark Region, where the central hardwood forest begins to merge into the western prairie, the land is about 60 percent forested. Here again most of the woodland is farmer-owned; frequently the farmer is in the livestock business. In order to feed his livestock, he commonly allows his livestock to graze in his woodland as well as on his open land, even though forage production in the woods is low.

Concerned over the optimum use of these wooded and related ranges, whether it be for timber or livestock, the Station is engaged in range research in this area.

High production of both timber and forage on the same acre is not feasible in the Ozarks because of the silvicultural requirements of the timber species and the ecological requirements of the forage plants. A well-stocked hardwood stand,

Good cows and good trees don't grow on the same acre of land.



for example, does not produce enough forage to be considered in an intensive stockraising operation except in an emergency. On the other hand as much forage can be produced on 1 acre of open land as is produced on 50 to 100 acres of well-stocked timberland. This suggests that if a farmer needs more grazing land it might be better to clear a few acres of his timberland and use the remaining timbered areas exclusively for growing trees.

What then is the best way to convert woodland to rangeland? Our research has shown that aerial spraying with herbicides, prescribed burning for seedbed preparation, seeding with introduced or native forage species, and applying commercial fertilizer greatly increased forage production on Ozark forest ranges in southwest Missouri. On a forest range where past overgrazing had greatly reduced the desirable native forage species, just spraying the unwanted hardwoods was not enough. Seeding some adapted forage species and applying commercial fertilizers were necessary to obtain large early increases in production.

To round out our range work, we are studying production potential, costs and returns, carrying capacity, and grazing schedules on converted land.

RECREATION

So far we have been concerned with hardwood forests as producers of physical goods. But they also serve as playgrounds. And because more and more people have more and more opportunities to enjoy the outdoors, the recreational function of our forests is becoming increasingly important.

Hardwoods have special advantages for this use too. That "spice of life" — variety — is exemplified in the hardwood forest. The myriad plant species, their variety enhanced fourfold by seasonal changes, form an ever-fresh environment that beckons the outdoor pleasure-seeker to return again and again. Location is an advantage too — the hardwood forests are close to where the people are. So the potential for expanding forest recreation opportunities in the hardwood regions is tremendous. But again, the private woodland owners are in the driver's seat. Many of them have gone into the recreation business — 700 in the State of Ohio alone, for example. Success has been varied, however. The failures and marginal enterprises point up the need for more concrete information on organizing and managing such businesses and evaluating local supply and demand.

Our research in forest recreation is aimed at finding ways for the private woodland owner to make full, profitable use of his forest recreation resources. We are now concentrating our work on two aspects of privately operated woodland recreation enterprises. First, we are identifying the factors that make these enterprises profitable, for example, location of the enterprise with respect to people, natural attractions, main highways, and so on. And second, we are evaluating present use and prospective future demand for private woodland recreational facilities.

"Camping in the woods" has become a family affair and the increasing demand for facilities is providing profitable opportunities for the enterprising private woodland owner.

Economics, Marketing, and Utilization of Hardwoods

The hardwood forest owner has need for information on the economics of timber growing, on marketing his products, and on timber utilization as well as on protecting and managing his forest resources. These are acute needs that we are attempting to satisfy in our research.

ECONOMICS

Little is known for sure about the woodland owner in the central hardwood region and about his interests in practicing forestry. So in our economics research we decided to learn more about the people who control the bulk of the forest resources in the region, to get better acquainted with them and find out exactly who they are and what their problems and attitudes are.

Take the typical woodland owner in southeastern Ohio, for example. We found that he is a farmer, laborer, or professional man more than 50 years old and owns less than 100 acres of woodland. He holds the land primarily for the timber that is on it but does little or nothing in the way of management. Reasons for this seeming paradox: "I don't know anything about forestry" or "I can spend my time and money more profitably some other way" or "Trees just take too long to grow." We concede that in the view of the owner, these are valid obstacles to good woodland management. But we feel they can be surmounted and are aiming our research toward that end.

Along with studying the owners themselves we are determining the profitability of growing timber on small tracts and the alternatives for investments in forestry practices. For example, we have a wealth of information on timber stand improvement inputs (cost and methods). However, very little information that the woodland owner can use is available on outputs and responses. We are now undertaking research to get this information. Initially, our emphasis will be on the high-valued species such as black walnut.

MARKETING

Now, how about the buyer? He has his problems too. His job is to obtain an adequate supply of suitable raw material as cheaply as possible and in turn manufacture it into a salable product. How can he cut costs or boost efficiency to increase profits? Before we can answer that we have to learn more about his operation. So in cooperation with mill operators, the men who buy and use hardwood timber, we are studying the marketing and processing practices of the industry. We haven't got the whole story as yet but we do have some good leads.

For one thing, uniformity of scaling, grading, and pricing is lacking. This situation is compli-

Well-manufactured and well-graded lumber means more sales.

cated by the diversity of products that can be made from hardwoods. Although this versatility is one of hardwood timber's virtues, it does tend to confuse the selling process. Clearly, a standardized, workable system of tree, log, and lumber grading is needed.

Do we have any words of wisdom as yet to help the sawmill operator himself? A few. If he wants to make more money per thousand board feet of product he would do well to: (1) keep better, more complete records (from our research, we have developed a recordkeeping system for him), (2) turn out a well-manufactured, graded product, (3) diversify his operation, his products, and his markets, and (4) most important of all, learn to become a better manager.

UTILIZATION

We are approaching the problems of utilizing hardwoods from three directions. First, we are searching for better, more precise methods of appraising, evaluating, and grading hardwood trees and logs. We want to be able to examine a tree or a log and predict with reasonable accuracy the lumber grade yields and value that can be derived from them. Such information will make the buying and selling of timber and rough products more precise and enable both parties to enter into a transaction with greater confidence and satisfaction. Appropriately, the hardwood phase of the Forest Service's nationwide Log and Tree Grade Program is headquartered at the Central States Station. So far, log-grade/lumber-yield studies, beginning with trees diagramed at the stump, have been conducted for black cherry, yellow-poplar, and silver maple to assist foresters in appraising standing timber. Also, tree grades are being prepared for the other commercially important hardwoods. Another study, being made in cooperation with the Forest Products Laboratory, involves evaluating the ability to predict yields of furniture cuttings from hard maple lumber by automatic data processing methods.

Our second approach is to make more of our low-grade timber economically available by finding ways to decrease the cost of getting it out of the woods. We are trying to determine the optimum combination of equipment, manpower, and techniques for logging various kinds and amounts of timber. We have found, for example, that a logger's profit can be doubled by bucking logs for grade instead of merely for length. Information soon to be published will reveal results of our studies on chainsaw use, crew size, and skidding equipment.

Our third approach is to try to find new and better ways to use hardwoods, especially the lower grades. Success here would improve markets and incomes for woodland owners as well as wood-using industries and provide more employment opportunities where they are most needed — in the economically distressed areas having high concentrations of forests.

In seeking new uses for low-grade hardwoods we are giving special attention to small outdoor structures for the farm and for recreation. Such structures, our investigations show, can be made economically from low-grade red oak and hickory. For picnic tables and benches, the hardness and weight of the hardwoods are distinct advantages, preventing damage and removal. Growing demand for outdoor recreation facilities could spur use of hardwoods for this purpose and stimulate local woodworking industries at the same time.

A far different "new use" for hardwoods is the development of wood "brick" tile and strip paneling. Expanding on an idea originating at the Southeastern Station, our wood product technologists made wooden bricks (individually and in strips) from various species of hardwoods and "laid them up" against interior walls to make a unique and striking wall paneling, truly a new look in interior decorating. The idea has caught on and the potential demand has attracted the interest of several manufacturers.

In our search for new and better ways to grade, harvest, and utilize hardwood timber, we sometimes discover and develop new tools and techniques for the commercial woodworker. Recent examples are a spindle guard for shapers and a lumber kicker for use on conveyorized cut-off saws. Even such by-products of research as these contribute, we feel, to the development of forestry and forest industry in the Central States.

1963 Publications

* Allen, Rufus H., Jr.

RATES AND DATES OF SHORTLEAF PINE SEED FALL. U.S. Forest Serv. Res. Note CS-13, 3 pp., illus.

(Eight to ten good seed trees per acre should produce adequate seed for natural regeneration on the Cumberland Plateau in Kentucky; 90 percent falls during November and December and only a third of all seed is sound.)

* Berry, F. H., and Bretz, T. W.

ATTEMPTS TO TRANSMIT THE OAK WILT FUNGUS BY SOIL AND ROOT INOCULATIONS. Plant Dis. Rptr. 47(3): 164.

(Results indicate that the oak wilt fungus may be transmitted between root systems in other ways besides root grafts.)

Berry, F. H., Brinkman, K. A., Bretz, T. W., and others.

RESEARCH, THE KEY TO THE DEVELOPMENT OF MISSOURI'S FOREST RESOURCES AND WOOD-USING INDUSTRIES. Mo. Agr. Expt. Sta. Bul. B-792, 52 pp., illus.

(Reviews problems of Missouri's forests and research being carried out by the Station and the University to solve them.)

* Bey, Calvin F., and Woerheide, John D.

UNDERPLANTED HARDWOODS FAIL TO MAKE MERCHANTABLE TREES. U.S. Forest Serv. Res. Note CS-12, 3 pp., illus.

(Hardwoods survived and grew poorly in southern Illinois and were low in quality when planted under nurse crops of planted black locust, planted shortleaf pine, and natural sassafras.)

Boggess, W. R., Minckler, L. S., and Gilmore, A. R.

EFFECT OF SITE AND THINNING INTENSITY ON GROWTH AND YIELD OF SHORTLEAF PINE PLANTATIONS IN SOUTHERN ILLINOIS. Ill. Agr. Expt. Sta. Forestry Note 105, 7 pp., illus.

(Stands on good- and medium-quality sites probably should not be thinned until trees are at least 20 years old; those on poor sites may be thinned 2 or 3 years sooner. Site quality also influences basal area to be left after thinning.)

Boyce, Stephen G.

METHODS FOR PRODUCING HIGH-QUALITY, FAST-GROWING COTTONWOOD. The Unit No. 98: 8-9, illus.

(Describes both European short-rotation plantation culture and the Central States Station's use of recurrent selection in establishing seed orchards of superior trees.)

Boyce, Stephen G.

SELECTING WHITE OAKS AS PARENT STOCK FOR GROWING HIGH-QUALITY LOGS. Cent. States Forest Tree Impr. Conf. Proc., Lafayette, Ind. 3: 15-18.

(Trees selected have eight or less branches on the lower 16-foot log counting both original branches and new branches appearing after non-permanent girdling is carried out to release suppressed buds.)

* Boyce, Stephen G., and Hosner, John F.

ALTERNATING STORAGE TEMPERATURES INCREASE THE GERMINATION OF YELLOW-POPLAR SEED. Jour. Forestry 61: 731-733, illus.

(Describes technique for breaking dormancy. Storage at one set of temperatures results in germination of all seed upon sowing direct or in a nursery. Storage at a second set of temperatures results in germination even before the end of 24 weeks storage and can be used as a germination test.)

* Boyce, Stephen G., and Neebe, David J.

REDUCE THE SPROUTING OF PRUNED WHITE OAK TREES WITH MOTOR OIL. U.S. Forest Serv. Res. Paper CS-3, 9 pp., illus.

(Motor oil (SAE 20W) proved best of several growth regulators, herbicides, defoliating compounds, oils, and solvents for reducing sprouting on pruned white oak.)

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*Available for distribution

* Boyce, Stephen G., and Schroeder, James G.
EVALUATING THE BENEFIT OF DEFECT REDUCTION IN HARDWOOD LOGS. Forest Sci. 9(3): 315-322, illus.
(Tells how to estimate number of logs of grades 1, 2, and 3 from number of surface defects on butt logs. Useful in picking good parent trees without having to cut them first.)

Brinkman, Kenneth A., and Phares, Robert E.
COST OF DIRECT SEEDING SHORTLEAF PINE IN THE MISSOURI OZARKS. Tree Planters' Notes No. 58: 29.
(Depending on the degree of release needed, direct seeding cost of $8 to $15 was one-half to one-third that for planting and provided from 1,500 to 6,000 well-distributed pine seedlings per acre.)

* Central States Station
'62 IN REVIEW. (1962 ANNUAL REPORT.) 36 pp., illus.
(Summarizes Station's work for 1962.)

Champagne, E. G.
LUMBER "GRADE-YIELD" RESEARCH MAY REDUCE CUTTING WASTE. Veneer Newsletter 226.
(Forest Products Laboratory is checking feasibility of a system to tell furniture manufacturers the grade of lumber most economical for particular cuttings. For electronic data processing in such a system, the Central States Station gathered data on defects in more than 10,000 board feet of hard maple lumber spread among five grades.)

Clark, F. Bryan
BLACK WALNUT PROGENY STUDY: A PROGRESS REPORT. Cent. States Forest Tree Impr. Conf. Proc., Lafayette, Ind. 3: 65-67.
(So far less than half the desired number of progeny trees with a potential for producing high-quality veneer have been found in this extremely variable species. But from these some 1-0 seedlings will be available for lifting and planting in spring 1963.)

* Clark, F. Bryan
ENDOTROPHIC MYCORRHIZAE INFLUENCE YELLOW POPLAR SEEDLING GROWTH. Sci. 140: 1220-1221.
(Seedlings infected with endotrophic mycorrhizal fungi grew much faster than seedlings not infected.)

* Clark, F. Bryan
WHITE ASH, HACKBERRY, AND YELLOW-POPLAR SEED REMAIN VIABLE WHEN STORED IN THE FOREST LITTER. 1962 Ind. Acad. Sci. Proc. 72:112-114, illus.
(Sassafras seed deteriorates rapidly in natural storage, but other seed in this study remained viable for several years.)

* Cooper, Glenn A.
DESIGN FOR A HARDWOOD BENCH. U.S. Forest Serv. Res. Note CS-11, 6 pp., illus.
(Gives plans, methods, and costs for using hardwood lumber to make out-door benches with backs.)

* Cooper, Glenn A.
SPINDLE GUARD MAKES SHAPER SAFER, MORE EFFICIENT. U.S. Forest Serv. Res. Note CS-5, 4 pp., illus.
(Guard designed for use in such straight-line shaping jobs as tonguing, grooving, and rabbeting, can easily be modified to fit any single-spindle shaper equipped with an adjustable holddown and fence.)

* Cooper, Glenn A.
USE RED OAK AND HICKORY FOR PICNIC TABLES. U.S. Forest Serv. Res. Paper CS-6, 20 pp., illus.
(Describes the advantages, construction, and cost of picnic tables made from hardwood lumber.)

* Cooper, Glenn A.
WOOD BRICK STRIP PANELING — A NEW WAY TO DECORATE. U.S. Forest Serv. Res. Note CS-10, 4 pp., illus.
(Like strip flooring, strip paneling is tongue-and-grooved for rapid installation with nails; brick effect results from cross-grooving individual strips at regular intervals and chamfering top and bottom.)

Cooper, Glenn A., and Merz, Robert W.
THE WOOD PRODUCTS PILOT PLANT FOR BETTER HARDWOOD UTILIZATION. North. Logger 12(2): 18-19, 44-45, illus.
(Describes pilot plant purposes and achievements in developing hardwood products not requiring defect-free parts or long, clear cuttings.)

* Crosby, John S., Johansen, Ragnar W., and Cooper, Robert W.
A NEW MACHINE FOR FOREST FIRE CONTROL: THE MODEL II MICHIGAN SAND CASTER. U.S. Forest Serv. Res. Paper CS-2, 30 pp., illus.
(Describes the machine, its operation, and the effectiveness of cast sand in fire-suppression trials in Michigan, Georgia, and Florida.)

* Dale, Martin E.
INTERPLANT ALDER TO INCREASE GROWTH IN STRIP-MINE PLANTATIONS. U.S. Forest Serv. Res. Note CS-14, 4 pp., illus.
(Ten species were planted. Heights of 10 species planted in eastern Kentucky were 4 to 50 percent greater after 5 years when European alder was used as a nurse tree.)

* Dochinger, Leon S.
ARTIFICIAL DEFOLIATION OF EASTERN WHITE PINE DUPLICATES SOME EFFECTS OF CHLOROTIC DWARF DISEASE. U.S. Forest Serv. Res. Note CS-16, 6 pp., illus.
(Premature shedding of needles associated with the disease may be responsible for the reduced growth also associated with the disease.)

Dochinger, L. S., and Seliskar, C. E.
SUSCEPTIBILITY OF EASTERN WHITE PINE TO CHLOROTIC DWARF. Phytopath. 53(8): 874.
(Abstract from unpublished talk; suggests causal agent acting on foliage is responsible for this disease rather than a virus.)

Ehrenreich, John H.
MEASUREMENT AND EVALUATION OF SOIL MOISTURE AND TEMPERATURE AND MICROCLIMATE IN ECOLOGICAL STUDIES. *In* Range Research Methods, U.S. Dept. Agr. Misc. Pub. 940, pp. 83-89, illus.
(Compares instruments currently available and gives general formulas for soil moisture, energy balance, and net solar radiation.)

* Ehrenreich, John H., and Aikman, John M.
AN ECOLOGICAL STUDY OF THE EFFECT OF CERTAIN MANAGEMENT PRACTICES ON NATIVE PRAIRIE IN IOWA. Ecol. Monog. 33:113-130, illus.
(Compares effects of burning, mowing, grazing, and protection on plant growth and yield and on plant environment.)

Finn, Raymond F.
FACTS ON IOWA FORESTS. Iowa Farmers Union Spotlight No. 11, Jan. 1963.
(Briefly describes Iowa forest resources from 1959 survey (Cent. States Forest Expt. Sta. Forest Survey Release 22) and calls for better forest management.)

Funk, David T.
BUD-GRAFTING YELLOW-POPLAR. Cent. States Forest Tree Impr. Conf. Proc., Lafayette, Ind. 3: 19-21.
(Tentatively recommends bud-grafting practices that could be used in establishing yellow-poplar seed orchards.)

* Funk, David T.
HYBRID POPLARS ON OHIO SPOIL BANKS. U.S. Forest Serv. Res. Note CS-8, 4 pp.
(In trials in southeastern Ohio, 50 hybrid poplar clones survived better and grew faster on Sewickley than on Pittsburgh spoil; the 10 clones that performed best are listed and evaluated.)

* Gansner, David A.
1961 CHARCOAL PRODUCTION IN THE CENTRAL STATES. U.S. Forest Serv. Res. Note CS-1, 4 pp., illus.
(Production for 1961 increased to more than 84,000 tons, nearly three times that for 1956, and was concentrated in Missouri.)

* Gansner, David A.
FOREST AREA IN MISSOURI COUNTIES. U.S. Forest Serv. Res. Note CS-4, 4 pp., illus.
(Forests occupied 34.5 percent of Missouri's total land area in 1959, slightly more than in 1947. There was an increase in the sparsely forested Northern Prairie Region where many acres of idle cropland and pasture reverted to forest; a decrease in the alluvial flatlands of southeastern Missouri resulted because of extensive clearing for agriculture.

* Gansner, David A.
HIGHLIGHTS TIMBER RESOURCES OF THE SOUTHERN CUMBERLAND REGION, KENTUCKY. U.S. Forest Serv. Resource Bul. CS-1, 26 pp., illus.
(Forest in 12 counties of this region covers 80 percent of the area, 6.1 percent more than in 1949; oak-hickory and central mixed

hardwoods are the most important types and sawtimber makes up about half the commercial forest.)

* Gansner, David A.
TIMBER VOLUME IN MISSOURI COUNTIES. U.S. Forest Serv. Res. Note CS-9, 4 pp.
(Gives volume of Missouri's growing stock and sawtimber in 1959 by regions and counties and for some species and species groups.)

* Gansner, David A., and Chase, Clarence D.
TIMBER RESOURCES OF THE MISSOURI PRAIRIE REGION. Mo. Agr. Expt. Sta. Bul. B797, 40 pp., illus.
(Forest now occupies about 15 percent of the land area or 2,861,000 acres, a 15 percent increase since 1947.)

* Gansner, David A., and Knutson, Robert G.
ILLINOIS PRODUCES 122 MILLION BOARD FEET OF LUMBER IN 1961. U.S. Forest Serv. Res. Note CS-3, 4 pp., illus.
(Shows number of sawmills by county and production by species.)

* Green, Alan W., and Pruett, Emerson W.
THINNING FAILS TO STIMULATE 50-YEAR-OLD WHITE PINE. U.S. Forest Serv. Res. Note CS-6, 4 pp., illus.
(None of the thinning intensities used restored the plantation to its former vigor and productivity.)

Harrold, Lloyd L., Marston, Richard B., and Schwab, Glenn O.
WATER CONSERVATION RESEARCH IN OHIO. Ohio Jour. Sci. 63(2): 49-55, illus.
(Reviews Ohio watershed problems and pertinent research by Agricultural Research and Forest Services of the U.S. Department of Agriculture and by the Ohio Agricultural Experiment Station.)

* Hay, C. John
INSECT IMPACTS ON HARDWOODS. Soc. Amer. Foresters Proc. 1962: 139-142.
(Losses caused by defoliating and boring insects are sometimes difficult to assess but, the obvious ones are serious and they show that we need to learn more about protecting hardwood forests.)

Hay, C. John
OHIO TIMBER POTENTIAL RATED HIGH, BUT LANDOWNERS MUST CARE FOR TREES. Buckeye Farm News 43(3): 15, illus.
(Describes seriousness of degrade due to red oak borer infestation of hardwood trees and tells how to control the pest by timber stand improvement.)

Hosner, John F., and Minckler, Leon S.
BOTTOMLAND HARDWOOD FORESTS OF SOUTHERN ILLINOIS — REGENERATION AND SUCCESSION. Ecol. 44(1): 29-41, illus.
(On well-drained areas, tree succession begins with pioneer cottonwood and willow, progressing in the next generation to mixed soft-hardwoods. On poorly drained areas, succession begins with buttonbush, tupelo, and cypress, progressing only slowly into mixed hardwoods of pin and other oaks.)

* Jensen, Chester E.
THE LEAST SQUARES FIT OF AN ALGERBRAICALLY UNSPECIFIED FORM. U.S. Forest Serv. Res. Note CS-2, 4 pp., illus.
(Use of Least Squares graphing to bypass the sometimes difficult and slow task of describing complex forms algebraically.)

Johnson, Edward A.
SURFACE WATER. Trans. Amer. Geophys. Union 44(2): 562-568.
(Summarizes surface water research by federal agencies and U.S. universities in 1960, 1961, and 1962.)

* Jones, Thomas W.
FUMIGATION MAY END OAK EMBARGOES. Forest Prod. Jour. 13(12): 564, illus.
(Fumigation of saw logs with methyl bromide was successful under field conditions. No oak wilt fungus was recovered from treated logs.)

Kucera, C. L., Ehrenreich, John H., and Brown, Carl
SOME EFFECTS OF FIRE ON TREE SPECIES IN MISSOURI PRAIRIE. Iowa State Jour. Sci. 38(3): 179-185, illus.
(More trees were killed when fuel was dry and humidity low.)

Lane, R. D.
FOREST SERVICE RESEARCH IN IOWA. Iowa Soil and Water Mag. 7(2): 5-6 illus.
(Describes problems Forest Service scientists are seeking to solve in Iowa and how forests

contribute to the State's economic and social well-being.)

Lane, R. D.

WHITE OAK — PRESENT AND FUTURE. Wooden Barrel 31(4): 10-11, 16.

(Shows that young growing stock must be brought to maturity to meet industry's future needs and points out that this goal requires continuing and strengthened research on hardwood problems.)

* Leaphart, Charles D.

ARMILLARIA ROOT ROT. U.S. Dept. Agr. Forest Pest Leaflet 78, 8 pp., illus.

(Describes and evaluates the fungus, *Armillaria mellea* Vahl ex Fr. that causes a disease of trees sometimes known as shoestring root rot, resin flow, oak fungus, or, from its mushrooms, honey agaric.)

* Limstrom, G. A.

FOREST PLANTING PRACTICE IN THE CENTRAL STATES. U.S. Dept. Agr. Handb. 247, 66 pp., illus.

(Manual on establishing tree plantations in the Central States — planting and seeding, early care, insects and disease, suitable species for different products, soil conditions, and localities of the region.)

Limstrom, G. A.

PROPOSED SEED COLLECTION ZONES FOR THE CENTRAL STATES. Cent. States Forest Tree Impr. Conf. Proc., Lafayette, Ind. 3: 31-39, illus. (Zones and designations proposed are slightly modified from those used in the plant hardiness zone map prepared by the U.S. National Arboretum (1960).)

* Lockard, C. R., Putnam, J. A., and Carpenter, R. D.

GRADE DEFECTS IN HARDWOOD TIMBER AND LOGS. U.S. Dept. Agr. Handb. 244, 39 pp., illus.

(Describes and pictures log surface or end abnormalities that cause degrade in logs. Also notes tree and stand characteristics that warn of defects. Supersedes Agr. Handb. 4, "Log Defects in Southern Hardwoods, 1950.")

* May, Robert F.

PREDICTING OUTSLOPES OF SPOIL BANKS. U.S. Forest Serv. Res. Note CS-15, 4 pp., illus.

(Area of disturbance downslope can be predicted if the proposed highwall height and the original slope angle are known.)

* McCurdy, Dwight R.

OHIO'S PRIVATE OUTDOOR AND FOREST RECREATION ENTERPRISES. 49 pp., illus.

(Lists more than 700 such enterprises, classifies them by 13 kinds of recreation offered, and maps their location by Ohio counties.)

McCurdy, Dwight R.

OHIO'S PRIVATE OUTDOOR AND FOREST RECREATION INDUSTRY. Ohio Conserv. Bul. 27(12): 16-18, illus.

(Describes need for outdoor recreation facilities and summarizes findings reported in Station bulletin above.)

Merz, Robert W.

A PRIVATE-FOREST PLAYGROUND IN SOUTHERN ILLINOIS. North. Logger 12(1): 22-23, 44-45, illus.

(Raising of beef has given way to recreation in producing an income on Marshall Skelcher's 181 acres of open field and forest near the U.S. Crab Orchard Wildlife Refuge; offered for a fee are picknicking, camping, horseback riding, fishing, hunting, and both summer and year-around homes.)

* Micklewright, James T., and Dunmire, Daniel E., III

USE AIR-DRY DECKBOARDS FOR BETTER WOODEN PALLETS. U.S. Forest Serv. Res. Note CS-7, 4 pp., illus.

(Reusable hardwood pallets need to be repaired less often in the first year of service if air-dry rather than green lumber is used for deckboards, but they perform about the same whether air-dry or green lumber is used for stringers.)

Peters, Elroy J., and Vogel, Willis G.

INCREASING FORAGE PRODUCTION ON OZARK FOREST RANGES BY SPRAYING, SEEDING, AND FERTILIZING. 1963 Agron. Abs.: 121.

(Following killing of trees with 2,4,5-T, seeding a fescue-lespedeza mixture increased herbage yields more than seeding of native grasses or no seeding; fertilizing increased production of fescue-lespedeza but not of native grasses.)

* Plass, William T., and Green, Alan W.
PREPLANTING TREATMENTS FOR BRUSHY OLD FIELDS IN SOUTHERN ILLINOIS. U.S. Forest Serv. Res. Paper CS-1, 8 pp., illus.
(Six brush treatments were tried before planting shortleaf pine, white pine, and white oak. On "short brush" areas (brush less than 10 feet tall) discing or mowing and spraying the stumps with herbicides resulted in faster growth for shortleaf pine only. On "tall brush" areas killing brush with a basal spray of herbicide increased growth on all three species.)

* Roach, Benjamin A.
SOMETHING NEW IN HARDWOOD MANAGEMENT. The Unit No. 98: 42-46, illus.
(Explains clear cutting and even-aged management for central hardwoods and inadequacy of traditional selection cutting.)

Ryker, Russell A.
EFFECT OF HUMIDITY DURING ARTIFICIAL EXTRACTION ON THE SUBSEQUENT VIGOR OF PINE POLLEN. Cent. States Forest Tree Impr. Conf. Proc., Lafayette, Ind. 3: 41-44, illus.
(Pollen vigor, as reflected in tube elongation, is improved by extraction under high humidity.)

* Sander, Ivan L.
BULLDOZE OR DISK TO REGENERATE SHORTLEAF PINE. U.S. Forest Serv. Res. Paper CS-8, 12 pp., illus.
(Bulldozing of logged sites (and disking to a lesser extent) result in more shortleaf pine seedlings free to grow, fewer competing hardwoods, and shorter competing vegetation after 4 years than no treatment.)

* Seidel, Kenneth W.
GERMINATION OF TREATED SHORTLEAF PINE SEED. U.S. Forest Serv. Res. Paper CS-5, 12 pp., illus.
(Seed stood up well under stratification and repellent treatment. Resulting protection from predators and faster germination are both valuable in direct seeding and outweigh a slight reduction in total germination that occurs.)

Seliskar, C. E.
OAK WILT. *In* Internationally Dangerous Forest Tree Diseases. U.S. Dept. Agr. Misc. Pub. 939, pp. 86-88
(Gives characteristics, means of spread, and known control measures for the disease and lists susceptible oak species.)

* Vogel, Willis G.
PLANTING DEPTH AND SEED SIZE INFLUENCE EMERGENCE OF BEARDLESS WHEATGRASS SEEDLINGS. Jour. Range Mangt. 16(5): 273-274, illus.
(Emergence was greater when seed was planted ½ inch deep than when it was planted 1 or 1½ inches deep. Emergence was as good for straight-run seed as for separated large seed.)

Vogel, Willis G.
RANGE MANAGEMENT IMPORTANT IN CONSERVING SOIL MOISTURE. Mo. Farmer 55(2): 21, illus.
(Well-managed range retains moisture more readily than poorly managed range and produces more forage as a result.)

* Walters, Russell S.
PAST GROWTH OF YELLOW-POPLAR AND OAK REPRODUCTION KEY TO FUTURE. U.S. Forest Serv. Res. Paper CS-4, 6 pp., illus.
(A recent study in southeastern Ohio indicates that among several characteristics considered, the best indicators of the growth potential of oak and yellow-poplar seedlings are their immediate past growth and present crown position.)

* Whitten, R. R.
ELM BARK BEETLES. U.S. Dept. Agr. Leaflet 185, 8 pp., illus.
(Slightly revised from earlier U.S Dept. Agr. leaflet of same title and number. Describes both smaller European elm bark beetle and native elm bark beetle, their life histories, relation to Dutch elm disease, natural checks, and control measures.)

Williams, Robert D.
FALL-LIFTED HARDWOOD STOCK SURVIVES AND GROWS AS WELL AS SPRING-LIFTED STOCK. Tree Planters' Notes No. 57: 29-30.
(Time of lifting made no difference in survival and early growth of red oak, black walnut, sweetgum, yellow-poplar, and sycamore.)

* Williams, Robert D.
INDOLEBUTYRIC ACID FAILED TO AID BLACK WALNUT SEEDLING DEVELOPMENT. 1962 Ind. Acad. Sci. Proc. 72: 108-111, illus.
(Soaking roots in low concentrations at the time of transplanting had no significant effect on survival, height growth, or secondary root growth during the first 2 years.)

* Wollerman, Edward H.
BARRENNESS IS TOOL IN BORER CONTROL. South. Lumberman 207(2585): 119-120, illus.
(The chemosterilant metepa reduces locust borer reproduction; chemosterilants also hold promise against other wood-boring insects.)

* Worley, David P.
CALCULATING OPTIMUM PRODUCT COMBINATIONS FROM STANDING TREES. U.S. Forest Serv. Res. Paper CS-7, 17 pp., illus.
(A method is presented for determining the product or combination of products that will yield the highest return per tree. Examples for using this method in practical situations are given showing solutions and decisions based on the criterion of maximum returns.)

Wray, Robert D.
PRESCRIPTION FOR WOODLAND MANAGEMENT, Part 1. Ohio Woodlands 1(1): 11, 13-14, illus.
(Explains how even-aged management may be practiced through clear cutting at the end of a rotation from the 1962 publication, *Timber Management Guide for Upland Central Hardwood,* issued jointly by the Central States Station and the North Central Region.)

Wray, Robert D.
PRESCRIPTION FOR WOODLAND MANAGEMENT, Part 2. Ohio Woodlands 1(2): 11-12, illus.
(Second of two articles; described above.)

Wray, Robert D.
RESEARCHLIGHT ON YOUR WOODLAND. Ohio Woodlands 1(1): 9-10.
(Describes column that will report on research of the Central States Station and appear regularly in this new quarterly magazine published by the Ohio Forestry Association.)

Wray, Robert D.
RESEARCHLIGHT ON YOUR WOODLAND. Ohio Woodlands 1(2): 7, illus.
(Contrasts biological control of insects to traditional chemical control. Three approaches in biological control are described.)

Wray, Robert D.
RESEARCHLIGHT ON YOUR WOODLAND. Ohio Woodlands 1(3): 6.
(Recreation researchers at the Central States Station investigate wants of public and costs and returns of woodland recreation enterprise operators.)